

CLAIMS

1. A liquid ejection apparatus comprising:

a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion;

5 an ejection electrode provided on the liquid ejection head, to which a voltage is applied for generating an electric field to eject the droplet;

a voltage applying unit for applying the voltage to the ejection electrode;

10 a substrate including insulative material for receiving ejected droplets; and

an ejection atmosphere adjusting unit for keeping an atmosphere subject to ejection from the liquid ejection head, to a dew point of 9 degrees centigrade or more and

15 less than a water saturation temperature.

2. A liquid ejection apparatus comprising:

a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion;

20 an ejection electrode provided on the liquid ejection head, to which a voltage is applied for generating an electric field to eject the droplet;

a voltage applying unit for applying the voltage to the ejection electrode; and

a substrate including insulative material having a surface resistance of $10^9 \Omega/\text{cm}^2$ or less at least at the area to receive ejected droplets.

5 3. A liquid ejection apparatus comprising:

a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion;

an ejection electrode provided on the liquid ejection head, to which a voltage is applied for generating an

10 electric field to eject the droplet;

a voltage applying unit for applying the voltage to the ejection electrode; and

a substrate including insulative material provided with a surface treatment layer making a surface resistance
15 $10^9 \Omega/\text{cm}^2$ or less at least at the area to receive ejected droplets.

4. A liquid ejection apparatus comprising:

a liquid ejection head having a nozzle for ejecting a
20 droplet of charged solution from a tip portion;

an ejection electrode provided on the liquid ejection head, to which a voltage is applied for generating an electric field to eject the droplet;

a voltage applying unit for applying the voltage to
25 the ejection electrode; and

a substrate including insulative material provided with a surface treatment layer formed by coating of a surfactant at least at the area to receive ejected droplets.

5 5. A liquid ejection apparatus comprising:

a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion;

an ejection electrode provided on the liquid ejection head, to which a voltage is applied for generating an

10 electric field to eject the droplet; and

a voltage applying unit for applying the voltage of a signal waveform to the ejection electrode, a voltage value of the signal waveform at least partly satisfying V_s (V) of the following expression (A), where a maximum value of
15 surface potentials of an insulative substrate that receives ejected droplets, is represented by V_{\max} (V), and a minimum value of the same by V_{\min} (V).

$$V_s \leq V_{\text{mid}} - V_{|\max-\min|}, \quad V_{\text{mid}} + V_{|\max-\min|} \leq V_s \quad (\text{A})$$

Here, $V_{|\max-\min|}$ (V) is defined by the following equation (B),

20 and V_{mid} (V) by equation (C).

$$V_{|\max-\min|} = |V_{\max} - V_{\min}| \quad (\text{B})$$

$$V_{\text{mid}} = (V_{\max} + V_{\min}) / 2 \quad (\text{C})$$

6. A liquid ejection apparatus comprising:

25 a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion;

an ejection electrode provided on the liquid ejection head, to which a voltage is applied for generating an electric field to eject the droplet;

a detecting unit for detecting surface potentials of an insulative substrate that receives ejected droplets; and

a voltage applying unit for applying the voltage of a signal waveform, a voltage value of the signal waveform at least partly satisfying V_s (V) of the following expression (A), where a maximum value of surface potentials of an insulative substrate detected by the detecting unit, is represented by V_{\max} (V), and a minimum value of the same by V_{\min} (V).

$$V_s \leq V_{\text{mid}} - V_{|\max-\min|}, \quad V_{\text{mid}} + V_{|\max-\min|} \leq V_s \quad (\text{A})$$

Here, $V_{|\max-\min|}$ (V) is defined by the following equation (B), and V_{mid} (V) by equation (C).

$$V_{|\max-\min|} = |V_{\max} - V_{\min}| \quad (\text{B})$$

$$V_{\text{mid}} = (V_{\max} + V_{\min}) / 2 \quad (\text{C})$$

7. The liquid ejection apparatus of claims 5 or 6, wherein the signal waveform outputted by the voltage applying unit is a waveform maintaining a constant potential so as to satisfy V_s of aforementioned expression (A).

8. The liquid ejection apparatus of claims 5 or 6,
wherein the signal waveform outputted by the voltage
applying unit is a pulse voltage waveform and at least
either the maximum value or the minimum value of the pulse
5 voltage satisfies V_s of aforementioned expression (A).

9. The liquid ejection apparatus of claim 8, wherein a
condition that the maximum value of the pulse voltage
applied by the voltage applying unit is larger than V_{mid} and
10 the minimum value of the pulse voltage applied by the
voltage applying unit is smaller than V_{mid} is satisfied.

10. The liquid ejection apparatus of claims 5 or 6,
wherein a condition that, out of a difference between the
15 maximum value of the pulse voltage applied by the voltage
applying unit and V_{mid} , and a difference between V_{mid} and the
minimum value of the pulse voltage applied by the voltage
applying unit, one of the difference is larger than the
other difference.

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11. A liquid ejection apparatus comprising:

a liquid ejection head having a nozzle for ejecting a
droplet of charged solution from a tip portion;

an ejection electrode provided on the liquid ejection
25 head, to which a voltage is applied for generating an
electric field to eject the droplet;

a voltage applying unit for applying the voltage to the ejection electrode; and

a static eliminator arranged oppositely to an insulative substrate that receives ejected droplets, for
5 discharging the insulative substrate.

12. The liquid ejection apparatus of claim 11, wherein the static eliminator is an electrode for discharging, arranged oppositely to the insulative substrate that receives the
10 ejected droplets, and the apparatus further comprises an AC voltage applying unit to apply an AC voltage to the electrode for discharging.

13. The liquid ejection apparatus of claim 12, wherein the
15 ejection electrode and the electrode for discharging are the same electrode.

14 The liquid ejection apparatus of claim 11, wherein the static eliminator is a corona discharge type static
20 eliminator.

15. The liquid ejection apparatus of claim 11, wherein the static eliminator is a static eliminator which irradiates light to the insulative substrate to discharge the
25 insulative substrate.

16. The liquid ejection apparatus of any one of claims 1 to 15, wherein an inner diameter of nozzle is 20 μm or less.

17. The liquid ejection apparatus of claim 16, wherein the
5 inner diameter of nozzle is 8 μm or less.

18. The liquid ejection apparatus of claim 17, wherein the inner diameter of nozzle is 4 μm or less.

10 19. A liquid ejection method of a liquid ejection apparatus including a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion, an ejection electrode provided on the liquid ejection head applied with a voltage for generating an
15 electric field to eject the droplet, and voltage applying unit for applying the voltage to the ejection electrode, comprising the step of:

ejecting the droplet toward a substrate including insulative material in an atmosphere which is kept to a dew
20 point of 9 degrees centigrade or more and less than a water saturation temperature.

20. A liquid ejection method of a liquid ejection apparatus including a liquid ejection head having a nozzle
25 for ejecting a droplet of charged solution from a tip portion, an ejection electrode provided on the liquid

ejection head applied with a voltage for generating an electric field to eject the droplet, and voltage applying unit for applying the voltage to the ejection electrode, comprising the step of:

- 5 ejecting the droplet toward a substrate including insulative material having a surface resistance of $10^9 \Omega/\text{cm}^2$ or less at least at the area to receive ejected droplets.

- 10 21. A liquid ejection method of a liquid ejection apparatus including a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion, an ejection electrode provided on the liquid ejection head applied with a voltage for generating an
15 electric field to eject the droplet, and voltage applying unit for applying the voltage to the ejection electrode, comprising the step of:

- ejecting the droplet toward a substrate including insulative material provided with a surface treatment layer
20 making a surface resistance $10^9 \Omega/\text{cm}^2$ or less at least at the area to receive ejected droplets.

22. A liquid ejection method of a liquid ejection apparatus including a liquid ejection head having a nozzle
25 for ejecting a droplet of charged solution from a tip portion, an ejection electrode provided on the liquid

ejection head applied with a voltage for generating an electric field to eject the droplet, and voltage applying unit for applying the voltage to the ejection electrode, comprising the step of:

5 ejecting the droplet toward a substrate including insulative material provided with a surface treatment layer formed by coating of a surfactant at least at the area to receive ejected droplets.

10 23. A liquid ejection method comprising the steps of:

 forming a surface treatment layer on a substrate including insulative material, by coating a surfactant at least at the area to receive ejected droplets;

 ejecting the droplets onto the surface treatment layer
15 of the substrate from a tip of a nozzle, by applying an ejection voltage to solution inside the nozzle; and

 removing the surface treatment layer except for portions which the droplets adhered, after the ejected droplets are dried and solidified.

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24. A liquid ejection method of a liquid ejection apparatus including a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion, an ejection electrode provided on the liquid
25 ejection head applied with a voltage for generating an electric field to eject the droplet, and voltage applying

unit for applying the voltage to the ejection electrode,
comprising the step of:

applying the voltage of a signal waveform to the
ejection electrode, a voltage value of the signal waveform
5 at least partly satisfying V_s (V) of the following
expression (A), where a maximum value of surface potentials
of an insulative substrate that receives ejected droplets,
is represented by V_{\max} (V), and a minimum value of the same
by V_{\min} (V).

$$10 \quad V_s \leq V_{\text{mid}} - V_{|\max-\min|}, \quad V_{\text{mid}} + V_{|\max-\min|} \leq V_s \quad (\text{A})$$

Here, $V_{|\max-\min|}$ (V) is defined by the following equation (B),
and V_{mid} (V) by equation (C).

$$V_{|\max-\min|} = |V_{\max} - V_{\min}| \quad (\text{B})$$

$$V_{\text{mid}} = (V_{\max} + V_{\min}) / 2 \quad (\text{C})$$

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25. The liquid ejection method of claim 24, further
comprising the step of measuring the surface potentials of
the insulative substrate before applying the voltage to the
ejection electrode; and obtaining the maximum value V_{\max} (V)

20 and the minimum value V_{\min} (V).

26. The liquid ejection method of claims 24 or 25, wherein
the signal waveform of the voltage applied to the ejection
electrode maintains a constant potential that satisfies V_s

25 of aforementioned expression (A).

27. The liquid ejection method of claims 24 or 25, wherein the signal waveform of the voltage applied to the ejection electrode is a pulse voltage waveform and at least either the maximum value or the minimum value of the pulse voltage satisfies V_s of aforementioned expression (A).

28. The liquid ejection method of claim 27, wherein a condition that the maximum value of the pulse voltage is larger than V_{mid} and the minimum value is smaller than V_{mid} is satisfied.

29. The liquid ejection method of claims 27 or 28, wherein, out of a difference between the maximum value of the pulse voltage and V_{mid} , and a difference between V_{mid} and the minimum value of the pulse voltage, one of the difference is larger than the other difference.

30. A liquid ejection method of a liquid ejection apparatus including a liquid ejection head having a nozzle for ejecting a droplet of charged solution from a tip portion, an ejection electrode provided on the liquid ejection head, to which a voltage is applied for generating an electric field to eject the droplet, and voltage applying unit for applying the voltage to the ejection electrode, comprising the step of:

discharging an insulative substrate before ejecting the droplet by application of ejecting voltage to the ejection electrode.

- 5 31. The liquid ejection method of claim 30, wherein the discharging the insulative substrate is performed by applying an AC voltage to an electrode for discharging, the electrode arranged oppositely to the insulative substrate.
- 10 32. The liquid ejection method of claim 31, wherein the electrode for discharging is the same with the ejection electrode.
33. The liquid ejection method of claim 30, wherein the
15 discharging the insulative substrate is performed by using a corona discharge type static eliminator.
34. The liquid ejection method of claim 30, wherein the
20 discharging the insulative substrate is performed by using a static eliminator that irradiates light to the insulative substrate.
35. The liquid ejection method of any one of claims 19 to
25 34, wherein diameter of an ejection opening of nozzle is 20 μm or less.

36. The liquid ejection method of claim 35, wherein the diameter of the ejection opening of nozzle is 8 μm or less.

37. The liquid ejection method of claim 35, wherein the
5 diameter of the ejection opening of nozzle is 4 μm or less.

38. A method for forming a wiring pattern of a circuit board comprising the steps of:

employing the liquid ejection method according to any
10 one of claims 19 to 37; and
ejecting droplets of metal paste onto the substrate.